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Agricultural Research

Norman Borlaug— Father of the Green Revolution

"I like to dream. And sometimes one has to dream if he is going to stay sane in this world of ours."

These prophetic words by Norman E. Borlaug only suggest what motivates this modest American scientist. This one-time Iowa farmboy and plant geneticist created through genetic engineering new strains of wheat, corn, and rice which, when combined with more efficient use of fertilizer and irrigation, increased harvests fourfold in developing nations. His crusade to improve crop yields has staved off world famine and won him the Nobel Peace Prize, the title Father of the Green Revolution, and recently, the first Sterling B. Hendricks Memorial Lectureship Medal. Following are some of Borlaug's comments from a recent interview.

"When we talk about the world food problem now and in the future, we must talk about food for how many and within what time period. We must maintain a reasonable balance between population growth and our ability to produce those necessities essential for a decent, humane life. This begins with food, the first basic necessity. Without food, all the other things we take for granted—clothing, housing, education, and employment—are of secondary importance. Unless we are successful in doing this, we will have more and more social, economical, and political chaos in the world.

"The United States is a very privileged nation from the standpoint of our standard of living, because of our productive agriculture and our productive industry. In the short run, we will remain the largest exporters to international markets of food beyond our own needs. This is important from the standpoint of our own economy. Last year, our income from exporting agricultural produce was about $40 billion. We imported about $15 billion worth of products—mainly tea, coffee, rubber, and fruits. So we probably ended up with a net balance of $25 billion from agriculture. This is not an insignificant amount, recognizing the drain on our foreign exchanges for other essentials such as petroleum and very basic minerals.

"Today, we depend on the developing nations for many of our raw minerals. We are no longer like we were before 1930, when we were essentially self-sufficient within our own borders and could keep our factories running. So it behooves us to strive in every way possible to assist developing nations to overcome their hunger and misery and poverty by helping them to improve the productivity of their lands now under cultivation and become more self-sufficient agriculturally.

"Since many developing nations are already under the burden of very heavy population pressures with very little additional land that can be brought under the plow in the near future, the holding line must be to increase the productivity of each acre now under cultivation. To do this, we must help them develop the appropriate technology to increase yields on the land now under cultivation.

"I've struggled with this problem. I've seen in the last 37 years some very positive results in the so-called Green Revolution. The Green Revolution refers to the rather spectacular increase in yields per acre—first in wheat and then in rice and other crops—in the developing nations. These yield increases were the result of a properly applied technological package. This package included breeding high-yielding varieties, restoring soil to fertility levels required to permit these varieties to express their true genetic yield potential, and then manipulating rainfall or conserving irrigation water to produce these yields. And then, of course, controlling the enemies of production—weeds, insects, and diseases—through genetic resistance.

"This technological package had to be checked out on hundreds of farms to find out where it fit and how to modify it so it would fit better in areas where it had deficiencies. First in Mexico, then much of this technology, in the case of wheat, was transferred to the most densely populated parts of the world, such as India, Pakistan, and Bangladesh.

"When the drought of 1965 and 1966 hit India, we had already had 2 or 3 years' experience in exploring the feasibility of transferring this technology to this country. To our surprise, in a general way, we saw great similarities—if we changed the planting dates, if we simplified the system, and if we found out how to fertilize to restore the fertility of those particular soils. This had to be done by experimentation—on farms, not in laboratories.

"We had a high degree of success in transferring this technology package. But the technology package is only one aspect of changing production. Once we had the package and had checked it for its validity, we still had to harness it to political policies. Otherwise, the technology as good as it is will not be applied and there will be no change in production. We must see that the credit is available for small farmers to buy the inputs needed to obtain these yields and that pricing at the time of harvest will stimulate farmers to adopt this package.

"Then, can man use honest work, God's best medicine, to gain his own livelihood."

By Henry Becker III

Requests for copies of the Borlaug lecture should be sent to:
Ms. Leila Moran
Room 408
National Agricultural Library
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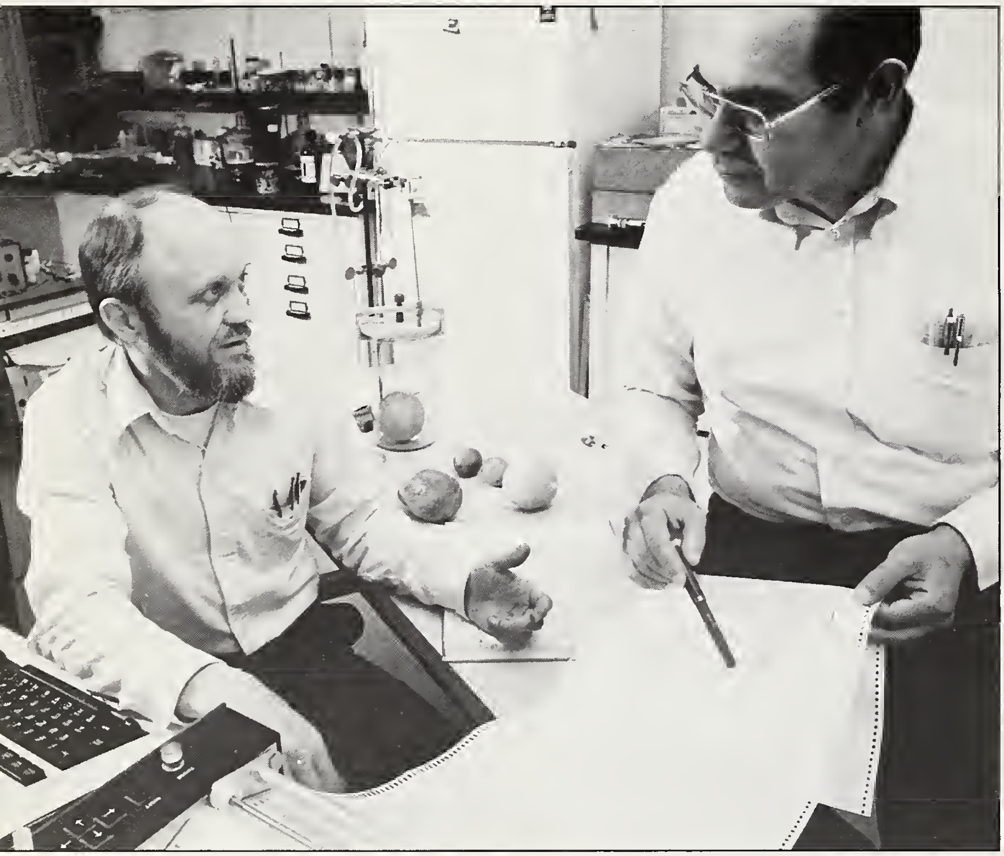
Cover: Detecting contraband foodstuffs at U.S. borders now requires more than sharp eyes and a sophisticated nose. Increased travel to the United States is bringing larger quantities of rapidly moving luggage, and automated inspection procedures are needed. ARS scientists are developing new instruments and techniques to provide this capability. Story begins on page 4 (0381W285-34A).

Contraband Foods



James Purcell (left) and Paul Magidman discuss infrared spectra used to "fingerprint" odors. A combination gas chromatograph and infrared spectrometer separates compounds in the odors and identifies them by distinctive peaks and valleys on a printout (0381W286-32).

"One of the long-term missions of ARS is the continued search for new knowledge, application of new technologies, and development of new methods to meet the needs of the Department's action and regulatory agencies. The following article is a view of the intertwining responsibilities, the ongoing cooperation, and the responsiveness of two sister USDA agencies, ARS and APHIS, and their cooperators to meet national needs for the health, safety, and welfare of the agricultural community and the Nation's public."

Dr. Terry B. Kinney, Jr.
Acting Administrator, ARS

Each year 45 million travelers enter the continental United States. Along with the usual souvenirs and remembrances, these travelers often bring with them prohibited agricultural products which may carry exotic pests and diseases not normally found in the country.

ARS researchers and cooperators are working to solve what is a multibillion dollar problem—the detection of contraband products entering the United States.

P. Gary Snyder, chief staff officer, Port Operations Development Staff of USDA's Animal and Plant Health Inspection Service (APHIS), explained the research challenge laid out by APHIS.

"We need an inexpensive instrument that can quickly probe, look at, or sniff baggage as it moves across a conveyor belt, and detect contraband agricultural products," he said.

APHIS tries hard to maintain a tight barrier against introductions of plant and animal diseases and pests. The agency carries out this responsibility primarily by working with other border clearance agencies, such as the U.S. Customs Service, to examine incoming travelers' baggage for contraband.

Snyder said that with increasing numbers of travelers, especially air passengers, there is an urgent need for a mechanized detection method.

Currently, he concedes that a considerable amount of contraband agricultural products carried by travelers entering the U.S. gets through without detection. "The problem of imported pests is intensified," Snyder says, "because they don't have natural enemies in this country."

In 1980, APHIS inspectors found over 502,000 pieces of prohibited fruits, vegetables, and plants in travelers' baggage; more than 14,000 quarantined insect pests were found and removed from that contraband. In addition, over 229,000 pounds of potentially dangerous meat and animal products were confiscated.

"It is difficult for travelers to believe that just one insect-infested orange, for example, can cause a widespread in-

festation leading to millions of dollars in lost agricultural crops, not to mention the additional millions of dollars spent for eradication measures," Snyder said.

Over a year ago, the Mediterranean fruit fly, which had been eradicated in the U.S. in 1966, was discovered in California—perhaps arriving in a piece of fruit carried by an unsuspecting traveler. About $28 million has already been spent by State and Federal governments to eradicate the fruit flies. Additional millions and an aerial pesticide application program will be necessary before eradication can be achieved. And if medflies spread to all of California's prime agricultural areas, the loss of crops plus eradication measures could total $450 to $500 million per year—not to mention the costs of a serious infestation in Florida and other fruit- and vegetable-producing states.

In addition to crops, the American livestock industry could suffer tremendous losses from the introduction of foreign animal diseases. For example, Rift Valley Fever is an African viral disease affecting cattle, sheep, and humans. It recently increased in virulence and is now rapidly spreading to countries in the Mediterranean area. The disease is a serious threat because during the incubation stage, humans can unknowingly carry it to any part of the world where the disease can be introduced into the livestock population. Livestock losses can be exceptionally high as recently experienced in Egypt where a 25-percent loss of the livestock population was attributed to Rift Valley Fever.

Pests like the khapra beetle, the Asiatic rice borer, the apple leaf roller, flag smut of wheat, and the giant African snail could all wreak havoc on U.S. agricultural productivity.

Reginald Handwerk, ARS national research program leader, Processed Fruits and Vegetables, said ARS research efforts are focused on three approaches to the contraband detection problem. One approach involves detecting food odors in luggage, another concentrates on identifying contraband through the use of x-rays, and the third utilizes sophisticated electromagnetic devices.

Any detection method must be able to deal with the wide range of objects and materials transported in luggage and the many designs and materials commonly used in luggage construction.

At the ARS Eastern Regional Research Center (ERRC), in Wyndmoor, Pa., researchers are attempting to identify the compounds responsible for the odors associated with contraband foodstuffs. Jim Purcell, research chemist, Physical Chemistry and Instrumentation Laboratory, explained that current efforts are aimed at identifying the volatile compounds in grapefruits, limes, passion fruit, mangoes, and coffee berries—fruits most often confiscated by APHIS—and fish and cured meats.

"Once the volatile chemicals in foods have been identified, they must be analyzed and evaluated in relation to other volatile compounds commonly carried in luggage, such as toiletry items and cosmetics, to establish methods for discrimination," Purcell explained.

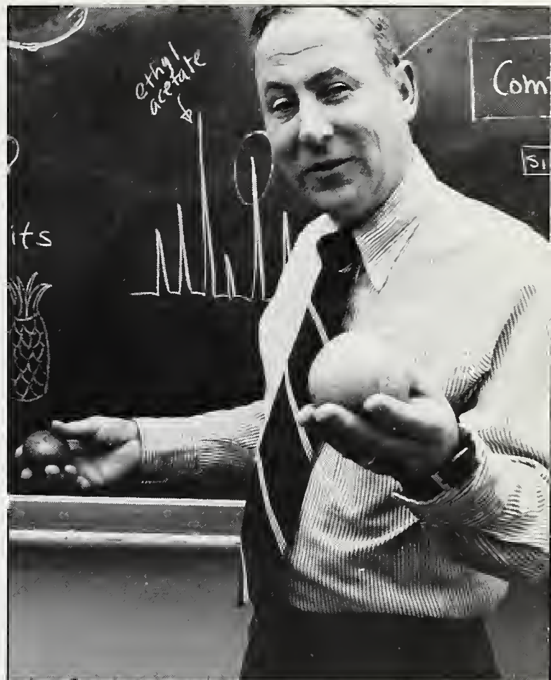
"We are actually looking for a limited number of volatile compounds which could serve as indicators of all contraband fruits, vegetables, and meats.

"Certain chemical compounds such as limonene have been identified in lemons and limes. However, limonene is also present in many lemon- and lime-scented shaving creams and lotions. So any detection method must be sensitive enough to differentiate between limonene in the fruit and limonene in other products," he said.

Researchers at the Monell Chemical Senses Center in Philadelphia are working with researchers at the ERRC to determine what background compounds might interfere with the detection of agricultural contraband.

"These might be odors associated with dirty laundry or perfumes and cosmetics," said John Labows of the Monell Center.

Purcell and Paul Magidman, research chemist, and Calvin J. Dooley, research physicist, at ERRC, are working with sophisticated analytical instruments that will separate and identify volatile compounds in agricultural products.



James Cavanaugh explains how insects, spores, and larvae can be prevented from entering the United States by electronic detection of host items (0381W284-7).

Once they catalogue the volatile marker compounds that will identify major contraband items of interest, the ERRC research team will study available methods for sensing them.

These methods are now in limited use in laboratory research. The primary question is whether adaptations can be made to meet APHIS' operating needs and budget limitations.

Another approach being investigated at the ERRC involves detecting carbon dioxide levels in the baggage.

"When fruits and vegetables are picked, they continue to breathe, giving off carbon dioxide," Purcell said. "In a closed surrounding, like a bag or suitcase, the level of carbon dioxide will be perhaps 100 times greater than the level of carbon dioxide found in the outside atmosphere."

James Cavanaugh, chief of ERRC's Physical Chemistry and Instrumentation Laboratory, said that the instrument finally developed must be able

Thomas Schatzki and Richard Young, electrical engineer, compare stored TV image of suitcase items with actual contents. Suitcase was opened after it emerged from x-ray scanner. Such comparisons will help Schatzki perfect an x-ray system to electronically detect contraband items (0881X1000-30A).

to detect a given property related to contraband foodstuffs, produce a signal, and be ready for the next sample rapidly. It must do so repeatedly and reliably for long periods of time and be able to convert the signal into some type of alarm to alert the APHIS inspector. The instrument also must be rugged and easy to use.

"To accomplish all these goals will require extensive modification of any existing analytical instrumentation and may require development of new technology," Cavanaugh said.

Researchers at ARS' Western Regional Research Center (WRRC) in Berkeley, Calif., have successfully used x-ray imaging to detect agricultural contraband in luggage.

T. F. Schatzki, research leader of the WRRC's Chemical and Structural Analysis Research Unit, explained that the x-ray imaging process is similar to that now being used in airports to detect weapons in luggage.

"So far we have been able to detect agricultural contraband items we know are in the luggage. The next step is to see whether it is possible to identify agricultural contraband if we don't know it is in the luggage," Schatzki said.

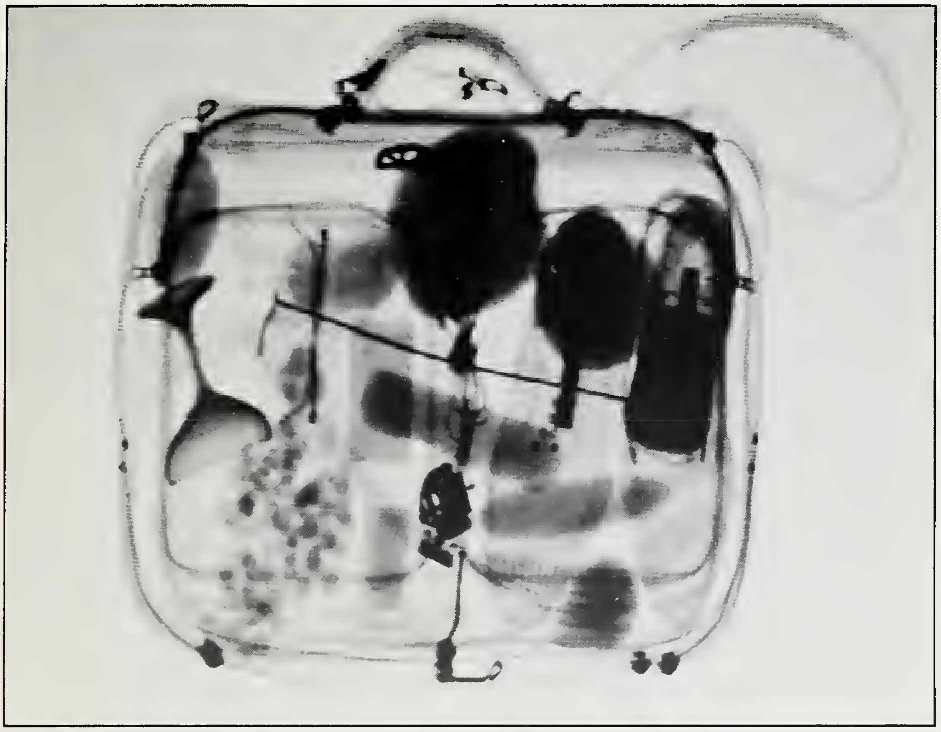
Snyder said APHIS will purchase x-ray imaging devices for field testing in the near future.

"One machine will be sent to Hawaii for pre-departure inspection of luggage," he said. "The other will be used by the APHIS Methods Development Laboratory in Hoboken, N.J., to test various contraband elements and to develop videotapes of contraband images for training inspectors."

Further sophistication of the x-ray system to electronically recognize images of contraband items will be Schatzki's next goal.

Scientists at Georgia Tech Engineering Experiment Station in Atlanta, in cooperation with ARS agricultural engineer Stuart O. Nelson, of the Richard B. Russell Agricultural Research Center in Athens, Ga., are working with various electromagnetic detection devices.

Ronald L. Seaman, electrical and biomedical engineer at Georgia Tech,



Video display of the x-ray image exposes contraband foods — avocado, mango, pineapple, pear, salami, grapes — among other items, such as shoes, cosmetics, and mementos, that a traveler might carry. Clothing, paper, and hollow items escape this type of detection (0881X1002-22A).

said this research is based on the distinct possibility that the dielectric properties—the interaction between the fruits, vegetables, and meats and an electromagnetic field—will introduce an alteration in the structure of an applied electromagnetic field. To be useful to the inspection process the structural alteration caused by the agricultural contraband would need to be different from the alterations caused by other suitcase items.

Currently, the scientists are studying ways to determine which alterations are produced by luggage items and which by agricultural contraband.

"The ultimate goal is to develop an instrument that could analyze the alterations and signal an inspector when agricultural contraband was in a suitcase," Seaman said.

During the study, four approaches have been investigated by the Georgia Tech scientists. Seaman says two appear most promising.

The short pulse radar (SPR) method emits a very brief pulse of electromagnetic energy which is directed toward the object to be scanned, a suitcase for example.

The return signal, which is measured, is displayed on a screen. Each object produces a different signal when the SPR bounces off it.

Seaman believes the SPR approach has possibilities because of its previous successful use by other researchers in obtaining profiles of underground soil and locating buried objects.

"Trying to locate agricultural products in a suitcase is similar to trying to find buried objects," Seaman explained.

Georgia Tech's experiments indicate that the SPR could detect fruit buried in 9 inches of sand and also provide information about the depth of the fruit, resulting in a three-dimensional picture.

Another promising candidate for detecting contraband involves the use of two parallel metal plates with an electrical field between them.

It appears potentially feasible to route baggage between the two plates while monitoring instruments that show alterations in values of selected electrical parameters.

Seaman said that the technology used in the Georgia Tech studies has never before been used to detect agricultural products.

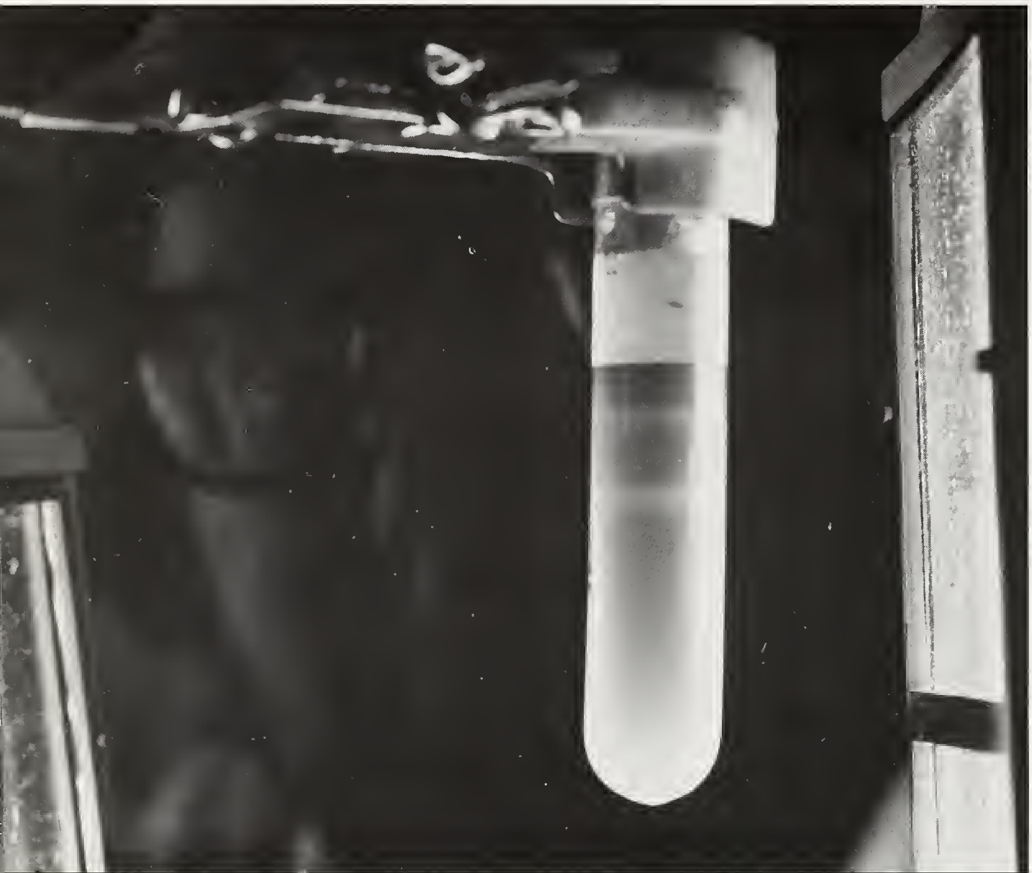
Handwerk believes that one of the three methods will be selected soon for further research, hopefully resulting in a detection method meeting all of the APHIS requirements. "The knowledge we've gained from this project will be put to many uses," he said.

"For example, x-ray imaging may provide information on when crops are ready for harvesting, based on the density of each piece of fruit or vegetable. Other nondestructive detection methods may prove successful for detecting spoilage in stored foods," Handwerk explained.

The potential is great for the use of instrument detection methodology in the food production, processing, and distribution system, according to Handwerk.

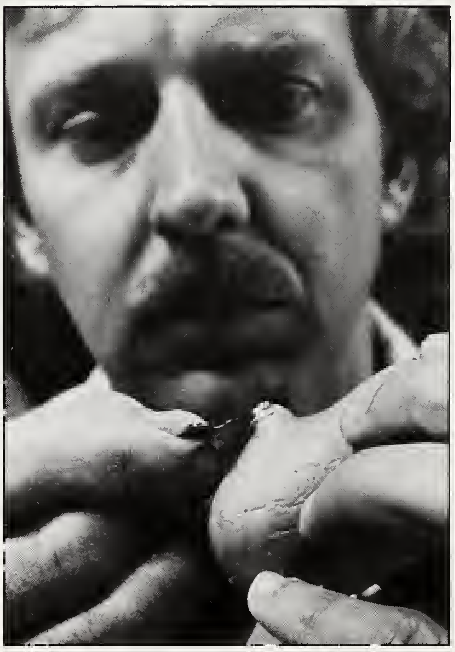
Reginald Handwerk is located at the Beltsville Agricultural Research Center-West, Building 005, Room 133, Beltsville, MD 20705. James Cavanaugh, Jim Purcell, Paul Magidman, and Calvin J. Dooley are located at the Physical Chemistry and Instrumentation Laboratory, Eastern Regional Research Center, 600 East Mermaid Lane, Philadelphia, PA 19118. T. F. Schatzki's address is Western Regional Research Center, 800 Buchanan Street, Berkeley, CA 94710. Stuart O. Nelson is located at the Richard B. Russell Agricultural Research Center, P.O. Box 5677, College Station Road, Athens, GA 30613. Ronald L. Seaman's address is Georgia Tech Engineering Experiment Station, Atlanta, GA 30332. Gary Snyder is located at USDA-APHIS, PPQ, Room 652, Federal Bldg., 6505 Belcrest Road, Hyattsville, MD 20782. John Labows is located at the Monell Chemical Senses Center, University of Pennsylvania, 3500 Market Street, Philadelphia, PA 19174.—(By Laura Fox, S&E, Washington, D.C.)

Gene-Splicing Prevents Potato Losses



Above: Dean Cress examines centrifuge tube containing cloned DNA (bottom band) and chromosomal DNA (upper band). Under UV light, the DNA fluoresces—thus facilitating its removal from the tube with a syringe. Cress and colleagues prepared the recombinant DNA later used to detect PSTV in potatoes (0681W630-2A).

Right: Sprout from a potato tuber, to be homogenized as part of the new DNA test, is removed by microbiologist Dennis Smith (0581W561-24A).



Using recombinant DNA technology, Robert Owens, ARS research chemist, and Theodor O. Diener, ARS research plant pathologist, both of Beltsville, Md., have devised a new method for screening large numbers of potatoes for potato spindle tuber viroid (PSTV), which causes a serious disease of potatoes.

The new screening method can be easily automated to certify viroid-free "seed" potatoes. The presently used automated testing procedures can only detect viruses and cannot be used to detect viroids.

PSTV is easily spread by touching the plant leaves with infested hands or tools, and through "seed" potatoes, true seed, and pollen. The disease becomes more severe as successive generations of infected potatoes are planted. Eradication of the disease once it is established is difficult, and no cure is known.

In severely infected crops PSTV disease can result in losses of over 50 percent, and potatoes that do develop are cracked and spindle-shaped, a feature which gave the disease its name. By detecting and eliminating diseased potatoes from the breeding stock, yields should be greatly increased.

Owens and Dean Cress, ARS research geneticist, made a mirror-image, complementary-DNA (cDNA) copy of the viroid ribonucleic acid (RNA) in a test tube. This cDNA was then inserted into *E. coli* bacteria that reproduced the cDNA as they multiplied. Each bacterial culture produced millions of copies of the cDNA for use in the PSTV test. The cDNA was removed from the bacteria and labeled with a radioactive marker.

To perform the test, a small piece of material from the potato is homogenized and a portion of the homogenate is fixed onto a thin membrane filter. These filters are then incubated with the prepared cDNA. Those spots containing PSTV combine with the radioactive cDNA and expose a photographic film placed against them. Sprouts, buds or eyes, or skin of a potato tuber can be checked for PSTV with the new test.

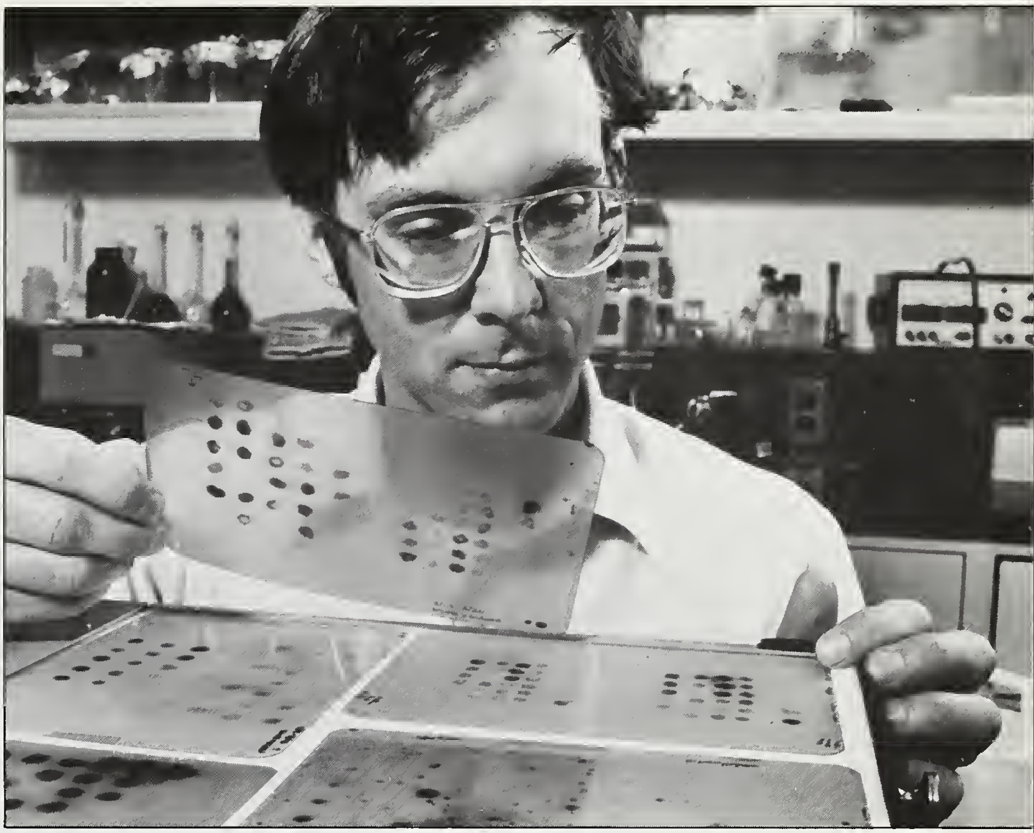
There are two tests now used to detect PSTV—bioassay in tomatoes and electrophoretic separation of plant nucleic acids. In the bioassay, when plants are inoculated with PSTV, the plants become stunted and the leaves curled. This test requires 6 to 8 weeks for completion, and mild PSTV infections may not be detected. Tests using electrophoretic separation techniques distinguish the PSTV from other RNA found in a normal plant cell, but testing is laborious and expensive with a large number of samples.

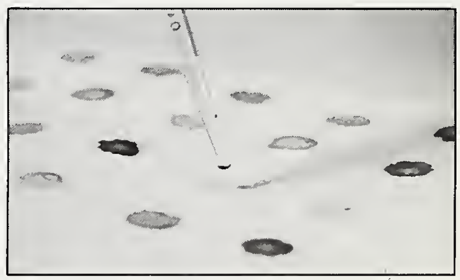
Potatoes provide, with greater efficiency, a more nutritionally well-balanced food than any other major crop. Therefore, this crop has great potential for countries with high populations and low income. Already a lowland tropical cultivar has been developed by the International Potato Center in Lima, Peru.

In warm climates, however, the PSTV disease is so severe that the crop cannot be grown unless the viroid is excluded from seed potatoes. Since the newly developed test can detect very small amounts of PSTV in seed tubers without affecting their usefulness, growers and breeders should be able to select viroid-free breeding stock and seed tubers.

In 1971, Diener discovered the new disease-producing agent, which he named "viroid." Viroids are approximately 1/40th the size of the smallest virus and are only a single molecule of the genetic material, RNA, in the shape of a hairpin or collapsed ring (see *Agricultural Research* magazine, Feb. 1972).

Robert Owens and Theodor O. Diener are located at the Plant Virology Laboratory, Room 252, Bldg. 011A, and Dean Cress is located at the Cell Culture and Nitrogen Fixation Laboratory, Room 107, Bldg. 011A, Beltsville, MD 20705.—(By Ellen Mika, ARS, Beltsville, Md.)





Top: Robert Owens examines developed film for PSTV using the new test. PSTV-containing spots on the membrane combine with radioactive cDNA and create dark spots on the photographic x-ray film (0681W628-28A).

Above: Homogenized sap from a potato sprout is applied to a nitrocellulose membrane filter before incubating with the DNA (0581W561-30A).

Left: Theodor Diener, who found and isolated the viroid, examines a tomato plant for characteristic PSTV symptoms—part of the old test for PSTV (0881W1020-13).

Two-Bale Cotton with High-Salt Water

Salt-tolerant cotton can be re-irrigated with salty drainwater. This helps dispose of a potential irrigation waste product and reduces demand for fresh water. (Photo courtesy of Grant Heilman.)

Brackish drainwater from irrigated fields is becoming more and more a serious disposal problem.

The problem can be lessened, however, by expanding the use of the high-salinity water by using it on salt-tolerant crops. From there it can be used on even more salt-tolerant non-food/feed/fiber crops—biomass.

To prove that point, ARS scientists got two-bale-an-acre cotton from field plots near Bakersfield, Calif., using brackish water containing as much as 6,000 parts per million (ppm) salt.

Two-bale cotton is a highly acceptable yield for growers in the area.

Those yields were as good as adjacent commercial cotton fields using water from the California aqueduct containing as little as 500 ppm salt.

The experimental field trials are a cooperative effort between ARS, the Kern County Water Agency, the Lost Hills Water District, and River West Farms, Inc. The California Department of Water Resources, California Water Resources Control Board, and the Water and Power Resources Service (Bureau of Reclamation) are assisting in funding the 4-year study.

The study is designed to test the idea, based on information from other studies under different conditions, that cotton can be profitably grown on a commercial scale with irrigation water of the quality anticipated to be available as drainwater from Kern County farms.

James D. Rhoades, ARS soil scientist who heads the project, said that although the study is being conducted in Kern County, the concept could have application throughout the irrigated areas of the country.

"Irrigation agriculture produces substantial volumes of brackish drainwater that are considered to be a waste and in need of disposal. For example, more

than 1 million acre-feet of return flow from irrigation in the Coachella and Imperial Valleys of California is disposed of each year into the Salton Sea.

"About 200,000 acre-feet of drainwater from the Wellton-Mohawk Irrigation and Drainage District of Arizona is discharged each year into the Gulf of Baja, Calif.

"By the year 2000, the Interagency Drainage Program (California) predicts that facilities to dispose of 425,000 acre-feet of drainwater annually from the San Joaquin Valley will be required to alleviate rising water tables in the valley trough.

"If this water could be put to a useful purpose, not only would it conserve a valuable resource, but also it would reduce the size of the conveyance systems required to dispose of it," Rhoades says.

At Bakersfield, the researchers irrigated cotton with three levels of salinity—low salinity water, about 500 ppm, from the aqueduct; high salinity water, about 6,000 ppm, from brackish wells; and a mixture of the two, about 3,000 ppm.

Yield quantities after ginning show that lint and seed were unaffected by those salinity levels. Two bales of lint per acre were obtained on all plots, regardless of irrigation water quality. Those high yields with saline water were thought possible because cotton is known to be one of the most salt-tolerant commercial crops.

Although cotton is highly salt tolerant, appropriate irrigation management is probably crucial to good yields with highly saline irrigation water, and that is one of the main goals of the 4-year study—to develop management techniques that can be passed on to growers.

"Use of drainage waters to grow cotton and possibly other crops could reduce the volume of water to be disposed of by two-thirds. But before such a use for those waters can be recommended, answers to several questions need to be obtained through controlled field trials such as we are doing near Bakersfield," Rhoades says.

Kern County, the southernmost portion of the San Joaquin Valley, has a serious drainage problem, more so than the rest of the Valley.

Historically, farmers and ranchers pumped water from underground sources for irrigation. When those waters played out, reservoirs were built and water was imported from the mountains—last year 300,000 acre-feet went to Kern County. Outlets like the Kern River were dammed leaving no natural channels for drainage to leave the County. At present there are only about 2,000 acres drained by tile lines.

All irrigation water contains some salt. Transpiration by plants and evaporation concentrate the salt in the unused water. That saline water percolates down to the underground water table. In Kern County, the water table is "perched" above an impermeable clay hardpan about 40 feet below the surface in some spots. Over the years, the brackish water has risen and is within 5 feet of the surface in a few places and at the 10-foot level over a wide area.

Nearly 28,000 acres in the County are now in what officials call a drainage problem area. Projections are that by 1985 about 100,000 acres will be in trouble and by 2005 nearly 137,000 acres will be in the same fix unless something is done.

That "something" will probably be a drainage canal to take the waste waters out of the Valley. Ways of using drainage water on a succession of salt-tolerant crops to concentrate the salt may be a means of cutting the size of that canal.

One of the next steps in the study is to concentrate the saline drainage water even further with its use on non-food/feed/fiber crops as mentioned before. Biomass, which may even include various weeds, may one day be turned into some form of energy.

James D. Rhoades is located at the U.S. Salinity Laboratory, 4500 Glenwood Drive, Riverside, CA 92501.—(By Paul Dean, ARS, Oakland, Calif.)

Winter Pasture on Small Watersheds

Feeding cattle all winter on small pastures is damaging to the pastures and increases nutrient losses in runoff, says Lloyd B. Owens, ARS soil scientist.

While the total nitrogen lost per year, about 13 pounds per acre, is not large, the results of the research suggest that rotating cattle on small pastures during the winter months would reduce nitrogen losses. Rotation would also reduce damage to grass caused by the concentration of animals.

Most of the nitrogen loss came during the winter period, November through April, Owens pointed out. Pastures used only during the grazing season, May through October, lost an average of less than half a pound of nitrogen per acre each year.

Owens also mentioned that the annual nitrogen losses were less than nature's contribution of 16 to 19 pounds of nitrogen delivered annually on each acre by an average year's rainfall.

He compared runoff from four orchardgrass pastures for 5 years at ARS' North Appalachian Experimental Watershed, Coshocton, Ohio.

Cattle were rotated on all four pastures during the grazing season. They were confined to one pasture and fed hay during the November to April period.

Owens also measured rainfall, runoff water, subsurface flow (from springs downhill from the pastures), soil losses, as well as nitrogen content of the water. Fifty pounds of nitrogen fertilizer per acre was applied on the pastures.

Lloyd B. Owens is located at the North Appalachian Experimental Watershed, P.O. Box 478, Coshocton, OH 43812.—(By Ray Pierce, ARS, Peoria, Ill.)

Toward Better Control of Boll Weevils

Boll weevil feeds on cotton bloom (which would soon become the cotton boll). Eventually, this will cause the bloom to drop. Farmers individually spend $300 a year to control boll weevils and other cotton pests (BN-24072).

Boll weevils for mass release in suppression programs can be genetically selected for longer life expectancy after exposure to a sterilizing dose of gamma radiation.

This is good news for the South—and particularly for planners of area-wide efforts designed to restrict the population of the South's number one cotton insect to lower levels that are not economically significant. Poor survival of radiation-sterilized boll weevils is limiting the use of this potential biological control technique.

Genetic selection for ten generations in a boll weevil strain increased the percentage surviving 14 days after irradiation from 35 percent to almost 80 percent in studies by ARS geneticist David T. North of the Metabolism and Radiation Research Laboratory, Fargo, N. Dak., and Franklin D. Enfield, geneticist, and Rebecca Erickson, senior laboratory technician, at the University of Minnesota, St. Paul.

Life expectancy after irradiation was increased about four days by the tenth generation of selection.

Many additional generations of selection are needed to determine how much the boll weevil's post-irradiation life-span might eventually be lengthened, Enfield and North say.

In preliminary tests, selection for greater survival after irradiation has not reduced sterility produced by irradiating male boll weevils, the geneticists say. In a population suppression effort, the radiation-sterilized males would be mass-released to mate with native females, but these matings would produce no offspring.

The geneticists established the laboratory boll weevil colony by crossing 21 males collected from six states with females of an ebony strain. They maintained 21 separate male lines of 350 adults each until the fourth generation, when they took 10 males and 10 females from each line to form a random-mating population. They took 30 males and 60 females from this population after four more generations to initiate the selection process.

Thirty-five males were each mated to two females in the selected population every 49-day generation.

In each generation, the geneticists usually saved four males and four females per family for breeding and exposed the remaining adult boll weevils to 10 krads of cobalt-60 gamma rays two days after emergence. Unirradiated weevils from the best surviving families then produced the next generation.

Cumulative effects of recurrent selection for longevity were checked every fourth generation.

After four generations, 20.7 percent more boll weevils of the selected population survived 14 days after irradiation than survived in the control group. The proportion was 42.4 percent more in the selected population after eight generations.

Results from early generations of selection provide evidence of genetic variability for survival after irradiation, North says, and also that population improvement for this characteristic can be made through family selection.

Franklin D. Enfield and Rebecca Erickson are in the Department of Genetics and Cell Biology, University of Minnesota, St. Paul, MN 55108. David T. North is at the Metabolism and Radiation Research Laboratory, State University Station, Fargo, ND 58105.—(By Walter Martin, ARS, Peoria, Ill.)

Wild Goatgrass Gives Greenbug Resistance to Wheat

Thanks to a wild goatgrass from Afghanistan, genetic resistance to damage by the greenbug can be bred into future wheat varieties.

The wild relative of wheat was little affected by greenbug toxin, ARS geneticist Leonard R. Joppa observed, in a season when susceptible wheats were damaged. Joppa, plant pathologist Roland G. Timian, and geneticist Norman D. Williams have transferred the greenbug resistance in the goatgrass to wheat.

Joppa says the gene for resistance, inherited as a simple dominant, should be readily transferable to winter and spring wheats.

The greenbug is a small, sap-sucking aphid that is generally distributed throughout the United States. It is most often damaging to wheat and other small grains in early spring on the Central and Southern Great Plains. The greenbug causes much of an estimated $80 million annual loss to wheat by insects in Oklahoma alone.

A two-step breeding procedure was necessary in transferring the resistance because goatgrass and common wheats—spring wheats, except durum, and winter wheats—have different numbers of chromosomes.

Joppa, at Fargo, N. Dak., first fertilized Langdon durum, which has 14 pairs of chromosomes, with pollen from the goatgrass, which has 7 pairs of chromosomes. He then doubled chromosome numbers in five resulting plants by inverting the young seedlings in a 0.2 percent solution of colchicine for 4 to 5 hours.

Those second-generation plants with 21 pairs of chromosomes, the same number as in common wheats, were then grown to produce seed for crossing with two greenbug-susceptible common wheat breeding lines. Joppa grew these crosses, their greenbug susceptible parents, and Langdon durum in cages, where they were exposed to locally collected greenbugs.

Sap-sucking greenbugs, members of the aphid family, cause millions of dollars of losses to wheat growers each year. Resistance to greenbugs can be transferred to wheat with a gene from Afghanistan goatgrass, a wild relative. (Photo courtesy of Grant Heilman.)

The crosses carrying goatgrass genes were highly resistant to the toxin produced by the greenbug. Most Langdon plants and those of the common wheat breeding lines used in the final crosses were dead within 15 days.

Genetic resistance in the host plant would be the most economical greenbug control, Joppa believes. Treatment with registered insecticides is expensive, and considerable damage can occur before farmers recognize the problem if conditions are favorable for rapid buildup of greenbug populations. A suggested seed treatment with certain systemic insecticides provides control only during the seedling stage.

Leonard R. Joppa and associates are located in Walster Hall, North Dakota State University, Fargo, ND 58105.—(By Walter Martin, ARS, Peoria, Ill.)

Low-Input Barley Designed for Dry Lands

A "low-input" feed barley that requires only one irrigation treatment and no nitrogen fertilizer while yielding as much as 4,000 pounds per acre was released to seed breeders this summer.

Designed for arid and semiarid areas of the world like this country's Southwest, the barley does extremely well where rainfall comes in sporadic downpours and where irrigation water is limited either by allotment or expense.

As yet unnamed and known as Composite Cross XXXIX, seed could be available to farmers in about 3 years.

Composite Cross XXXIX is a short-season variety that in the Southwest matures about 2 weeks before cotton planting begins and could be used as a second crop to cotton with little cost.

When planted around the Tucson area in December after only a single 6-inch irrigation treatment, the variety matures about May 1. Present-day "irrigated" barley varieties require about 24 inches of irrigation water and, of course, yield higher than the low-input variety. They in turn require nitrogen fertilizer applications, however.

The new variety was developed by Robert T. (Tom) Ramage, Jr., ARS agronomist, Tucson, Ariz. who says, "A barley that will produce an economic yield following a single rain—or a single irrigation—of sufficient magnitude would greatly enhance barley production in arid and semiarid areas like our Southwest, North Africa, or the Middle East."

It took about 7 years to develop the new variety from multiple crosses of drought-resistant plants.

Robert T. Ramage is located at the University of Arizona, Room 202, College of Agriculture, Tucson, AZ 85721.—(By Paul Dean, ARS, Oakland, Calif.)

Sunflower Hybrids Now Possible

By crossing commercial sunflower varieties like these with wild perennial sunflowers through a technique called embryo culture, scientists can transfer beneficial genes to make new hybrids. (Photo courtesy of Grant Heilman.)

Embryo culture has been adapted to permit crossing different sunflower species, called interspecific hybridization.

The technique will allow scientists to cross wild perennial sunflowers with current commercial plants that could result in the development of important future sunflower hybrids by transferring beneficial genes, such as disease resistance, insect resistance, hardiness, and others.

While embryo culture has been successful with many plant species, it has not until now been successful with sunflowers.

Embryo culture involves removing the microscopic embryo from immature seed and nurturing it with the use of artificial media. The technique is successful where conventional methods of sunflower hybridization are not.

A barrier to crossing different species has been embryo abortion, caused by something in, or lacking in, the endosperm. Seed embryos get their food supply from the endosperm of the seed, but, interspecifc hybrid sunflower endosperm somehow allows the embryo to starve and die.

John M. Chandler, a graduate student at the University of California, Davis, under the tutelage of Benjamin H. Beard, ARS plant geneticist, takes the almost microscopic embryo from the immature seed before the embryo has a chance to die.

He places the embryo on an agar medium containing a high percentage of sugar. It is the high sugar, he says, that makes this method successful while other researchers' methods have failed.

The high sugar content of the medium keeps the embryo from germinating. By retarding germination, Chandler allows the embryo to gain strength and maturity.

The second step in Chandler's method involves transferring the embryo to a liquid medium containing a low percentage of sugar. There the embryo germinates and grows into a seedling capable of supporting itself when transferred to soil.

In 1979, there were 5.4 million acres of sunflowers harvested in four states—Minnesota, Texas, North and South Dakota.

Benjamin H. Beard and John M. Chandler are located at the University of California, Room 261, Hunt Hall, Davis, CA 95616.—(By Paul Dean, ARS, Oakland, Calif.)

Sunflower Seed Meal for Poultry

Dehulled and defatted high fiber sunflower seed meal (SSM) offers an effective protein substitute for soybean meal, fish meal, meat and bone meal, and other high protein materials, according to James L. McNaughton, ARS research nutritionist for the South Central Poultry Research Laboratory.

"SSM's usage is especially important when low-protein complete diets are desirable for mature poultry—for instance, commercial layers, turkey and broiler breeders, and commercial egg-type pullets." says McNaughton.

McNaughton reports that using dehulled, defatted sunflower meal containing 36 to 38 percent protein will satisfy the protein requirements of commercial layers and broiler hens. He sees SSM as more valuable in layer diets than in broiler diets and its use is accompanied by a reduction in levels of soybean meal and methionine (an amino acid) and increases in the level of fat.

To determine the effectiveness of high-fiber SSM as a replacement for soybean meal, two experiments were conducted using commercial laying hens to evaluate replacing 33, 66, and 100 percent protein from soybean meal with high-fiber SSM (36.1 percent protein).

Neither body weight change, egg production, egg weight, nor eggshell breaking strength was affected by the addition of SSM, McNaughton reports.

Data from the two experiments indicate that SSM may replace 100 percent soybean meal without adversely affecting laying-hen perormance.

In practical broiler diets, the maximum amount of SSM tolerated by broiler chicks, without adversely affecting broiler performance, appears to be 15 percent in all mash diets and 30 percent in pelleted feeds.

Laying hens may tolerate as much as 100 percent replacement of supplemental protein, such as soybean meal, by sunflower meal. Although feed consumption tends to increase when using

Grinding these sunflower seeds into meal and mixing it with lysine will make an excellent all-purpose, high-fiber feed for laying hens. (Photo courtesy of Grant Heilman.)

high-fiber SSM, this factor must be considered when evaluating economical alternatives.

McNaughton cautions that when formulating broiler, broiler-breeder, laying-hen, and turkey diets, it is important to remember that SSM is relatively low (1.02 to 1.78 percent) in lysine, protein's most important amino acid in the poultry diet. Therefore, improving low-lysine sunflower meal with synthetic lysine is one possible economical consideration.

James L. McNaughton is located at the South Central Poultry Research Laboratory, P.O. Box 5367, Mississippi State, MS 39762.—(By Neal Duncan, ARS, New Orleans, La.)

Innovative Rice Processing

Developing innovative procedures for using small, thin rice kernels that are usually lost or broken in rice processing has the potential for producing a new high-protein, food-grade flour, according to James I. Wadsworth, ARS chemical engineer, Southern Regional Research Center.

Thin rice kernels comprise 2 to 5 percent of a rice crop. The amount lost or destroyed in normal rice processing is important because the protein content of these kernels is 11 to 13 percent higher than that of regular rice and is comparable to experimental rice varieties that have been bred for protein.

Wadsworth envisions that by using screens, thinner rice kernels could be mechanically separated and isolated. Once separated, they could be processed into a brown rice flour to be used in food blends for infants in developing countries.

Working in collaboration with ARS chemist Jack Matthews and chemical engineer James J. Spadaro, Wadsworth also believes that handling the thinner kernels separately could reduce the energy for drying the rice crop. In freshly harvested rice, the moisture content of thinner kernels is 6 to 10 percentage points higher. The researchers feel that thinner kernels could be separated from the bulk of the rice before drying, shelled wet, ground into flour, and then rapidly dried with ambient air. The reduction in energy required for drying brought about by using this method would amount up to approximately 15 percent.

Besides offering new uses, the process could reduce processing losses, improve the quality of milled rice products, and increase the crop's market value.

The team used Starbonnet variety long-grain rice to study the differences in milling performance and milled rice quality that are related to the variation in the thickness of the rice kernels. The rough rice was separated into six thickness fractions and portions of each fraction were shelled and milled under identical conditions. Milling performance and quality characteristics were evaluated for each fraction.

(Photo courtesy of Grant Heilman.)

Shelling efficiency, milling yield, breakage, degree of milling, and incidences of chalky and damaged kernels were the principal areas explored.

Wadsworth says the information from this study provides a more detailed description of the rice kernel than has previously been available and identifies those rice processing areas where the potential exists for reducing processing costs and improving quality.

James I. Wadsworth, Jack Matthews, and James J. Spadaro are located at the Southern Regional Research Center, P.O. Box 19687, New Orleans, LA 70179.—(By Neal Duncan, ARS, New Orleans, La.)

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Agrisearch Notes

Microwave Blanching of Vegetables. Microwave-blanched vegetables compared unfavorably to water- or steam-blanched vegetables in ARS tests, losing flavor, nutritional content, color, and texture.

Vegetables are blanched or heated prior to freezing to inactivate enzymes that cause spoilage, to improve color, and to remove air so that more product can be placed in a package. Traditionally, hot water or steam has been used for blanching, but in recent years, much interest has arisen in the use of microwave ovens for this purpose.

ARS food technologist Stephen R. Drake, along with technician Jaquiline B. Thompson and Sarah E. Spayd, food scientist with Washington State University, all at Prosser, Wash., compared the effects of different blanching techniques on asparagus, green beans, green peas, and sweet corn.

The comparison study was conducted over a two-year period. Vegetables were washed and either water-, steam-, or microwave-blanched, cooled in water, packaged in plastic pouches, and frozen. Objective quality tests were made. Then samples of each vegetable blanched by each technique were presented in four separate trials to 15 randomly selected panel members who ranked the samples for color, texture, and taste according to personal preference.

In neither the objective nor the subjective tests were microwave-blanched vegetables as acceptable as water- or steam-blanched products. Nor was there any significant time gained using microwave blanching, as both water and steam blanching required only about 2 minutes.

Drake also notes that in the Prosser study, contrary to previous reports, there was little difference between the quality of water- and steam-blanched vegetables in either objective or subjective measurements, although water blanching might produce a slightly more flavorful product.

Stephen R. Drake is located at the Irrigated Agriculture Research and Extension Center, P.O. Box 30, Prosser, WA 99350.—(By Lynn Yarris, ARS, Oakland, Calif.)

Long-Staple Pima Cotton Impressive. Pima, a long-staple, high-quality cotton grown in the Southwest, continues to impress both scientists and growers with its length and quantity of yield.

In order to be classed "long-staple," cotton must be at least 1-3/8 inches long. Long-staple cotton like Pima goes into the manufacture of high-quality thread, yarn, and cloth. Growers receive premium prices for the lint. Upland cotton, a short-staple variety, is attractive to growers because of its high yield.

A recent survey of the "Quality of Cotton Classed Under the Smith-Doxey Act" conducted by USDA's Agricultural Marketing Service shows that in the Phoenix area 97 percent of the Pima cotton was 1-7/16 inches long, exceeding the standards. Three percent was 1-3/8 inches.

In the El Paso area—Texas, New Mexico, and eastern Arizona—76 percent of the cotton was 1-7/16, while 23 percent was 1-3/8. The rest, 1 percent, was 1-5/16.

A small portion—less than 1/2 percent—of the Pima in the Phoenix area was 1-1/2 inches long, an almost unheard of length.

Carl V. Feaster, ARS agronomist, Phoenix, is responsible for the Pima breeding program. Feaster says that when plant breeders set their sights on quality, usually quantity suffers, but this relationship is being minimized through the USDA-ARS Pima breeding program.

In 1977, Pima, while continuing to maintain quality, outyielded upland cotton in the El Paso marketing area.

A variety of Pima, called S-5 by plant breeders and growers and released for commercial use in 1975, accounted for 99 percent of the Pima acreage in 1979. It was the fifth consecutive year for the cultivar—rising from 10 percent in 1975, 80 percent in 1976, 94 percent in 1977, and 97 percent in 1978.

"When Pima S-5 was released, it was the most productive, earliest maturing, and shortest statured cultivar we had tested throughout the Pima belt," Feaster says.

Pima S-5, however, may be outclassed in several areas by some subsequent strains now in the process of being tested throughout the Pima belt.

Two of those cultivars look especially promising in various areas and under certain cultural practices, Feaster says, in that they outyield Pima S-5, mature earlier, and are shorter in stature.

"Early, productive, short-statured cultivars are essential to the short-season concept for reducing production costs, and that type of plant is adapted for integrated pest management schemes," the agronomist says.

Feaster has received several honors and world-wide acclaim for the Pima breeding program.

Carl V. Feaster is located at the University of Arizona Cotton Research Center, 4207 E. Broadway Rd, Phoenix, AZ 85040.—(By Paul Dean, ARS, Oakland, Calif.)